Cat.No.Y101-E1-03

OMRON

Temperature Controllers

SELECTION GUIDE

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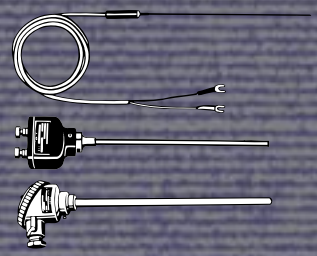
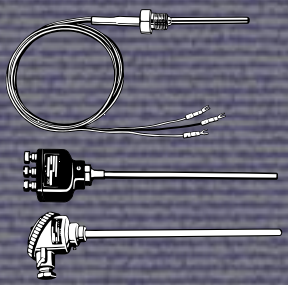
商品体系

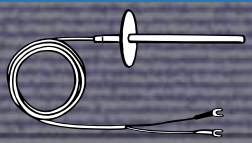
OMRON: Meeting All Your Tempe

入力機器

温度調節器







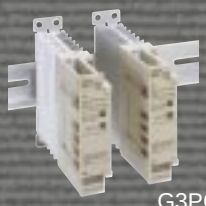
Output Devices

Cycle Control

Cycle Control Units

G32A-EA

G3PA



G3PC

ON/OFF Control

SSRs

G3PB (Single-phase)

G3PB (Three-phase)

G3NA

Digital Temperature Controllers

ES100P ES100X

Phase Control

Power Controllers

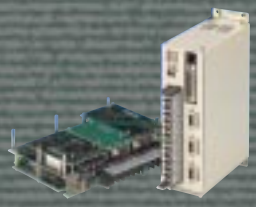
G3PX (Single-phase)

G3PX (Three-phase)

Modular Temperature Controllers

E5ZN

Multi-point Temperature Controllers



E5ZE-8□□□□B

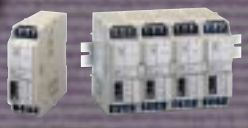
E5ZE-8□D1□B-V2
(DeviceNet)

PLC Units

CJ1W-TC C200H-TC/-TV/-PID CQM1-TC

Peripheral Devices

Block-type Switching Power Supplies
S8TS

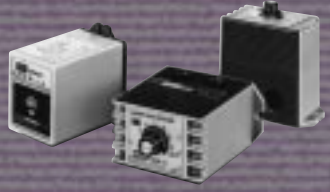


Data Recorder
E55A-E/-F

Interface Converters
K3SC

Switching Power Supplies
S8VS

Heater Burnout Alarms K2CU



Intelligent Signal Processors
K3NH/K3MA-L

Forming the Core of OMRON's Temperature Controller Lineup — The E5□N Series

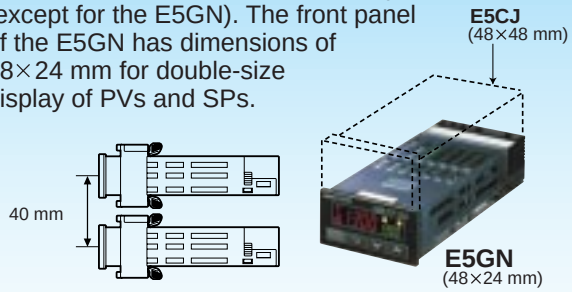
Equipped with nearly all the standard functions required in Temperature Controllers to allow use in a wide variety of machines and control panels.

A Variety of Different Sizes

The lineup includes the compact E5GN (48×24 mm) and the E5AN (96×96 mm), which has a large display and keys.

Compact

A depth of 78 mm allows these Temperature Controllers to fit into thinner control panels (except for the E5GN). The front panel of the E5GN has dimensions of 48×24 mm for double-size display of PVs and SPs.

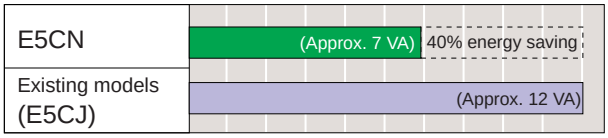


Improvements in Basic Functions and Performance

Equipped with the performance and functionality, including auto-tuning and self-tuning, to fulfill almost any kind of temperature control application.

Energy Savings and High Reliability

Unique power supply technology enables an energy saving of 40% compared to existing models (power consumption: approx. 7 VA). The suppression of heat generation and improved reliability ensure at least 3 years of use.



(Power consumption)

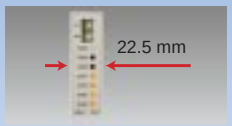
For smaller installations...

Downsize the installation by using a Programmable Terminal for both operation and display. These Temperature Controllers are recommended for applications not requiring setting and display at the front of the panel.

E5ZN
Modular Temperature Controllers

Simpler Setup

Ultra-slim model of width 22.5 mm. Side connectors are used for power supply and RS-485 connections between Units and so wiring between the panel surface and the panel interior is only required for the display device.

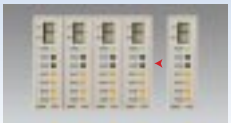


Less Maintenance Required

The number of temperature input points can be increased without adding operating panels or restructuring the control panel. Temperature control can be performed for 2 channels per Unit up to a maximum of 32 channels.

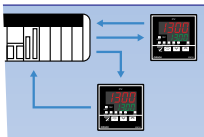
Expansion According to Necessity

The Temperature Controller can be replaced without changing the wiring, meaning less work and fewer wiring errors.

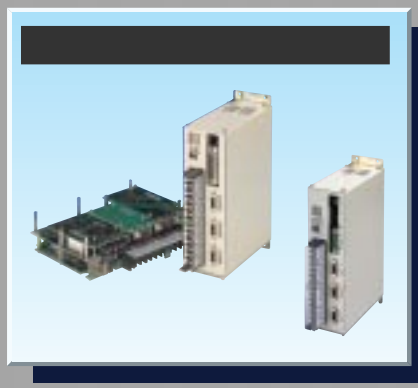


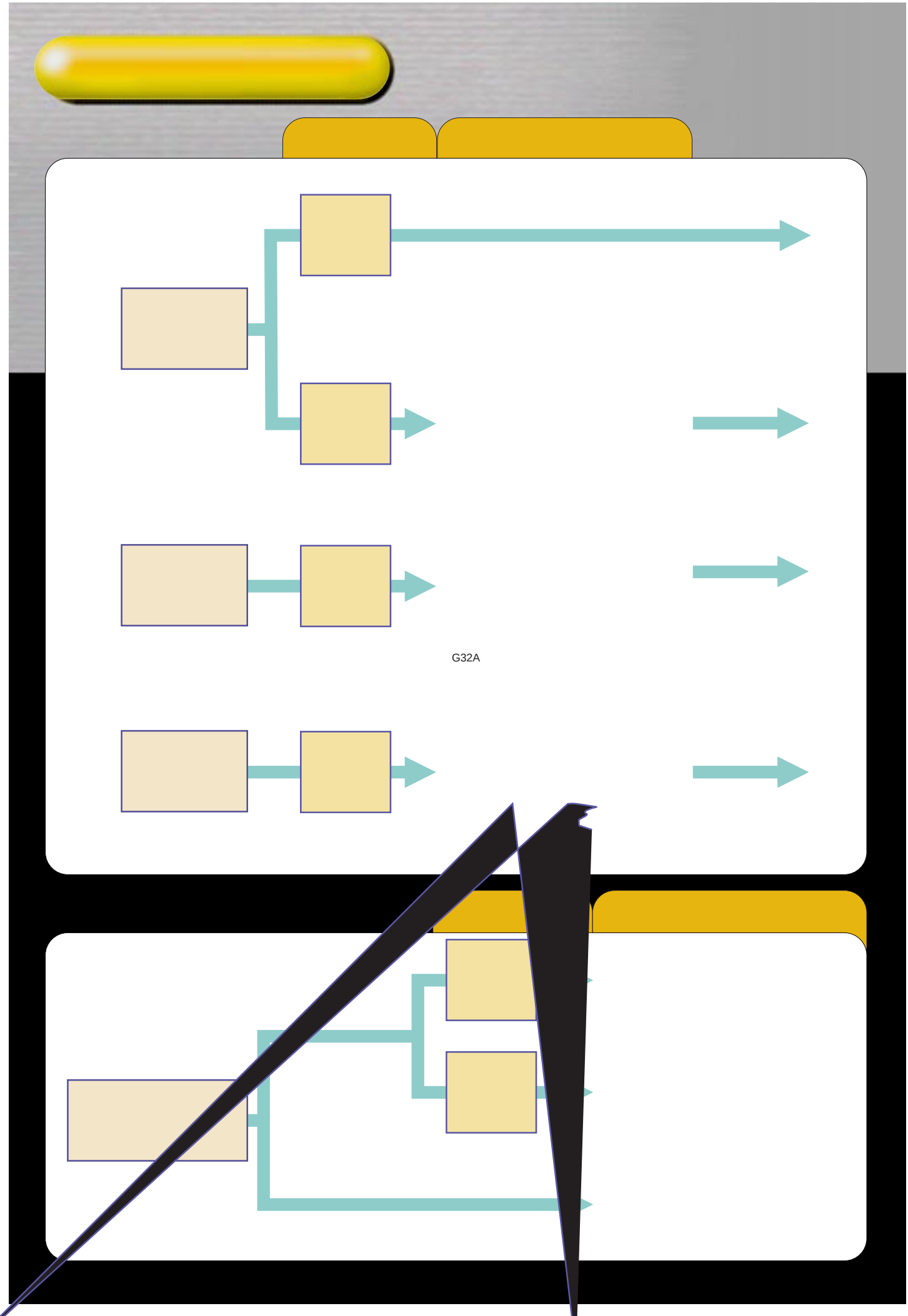
Easier Software Development

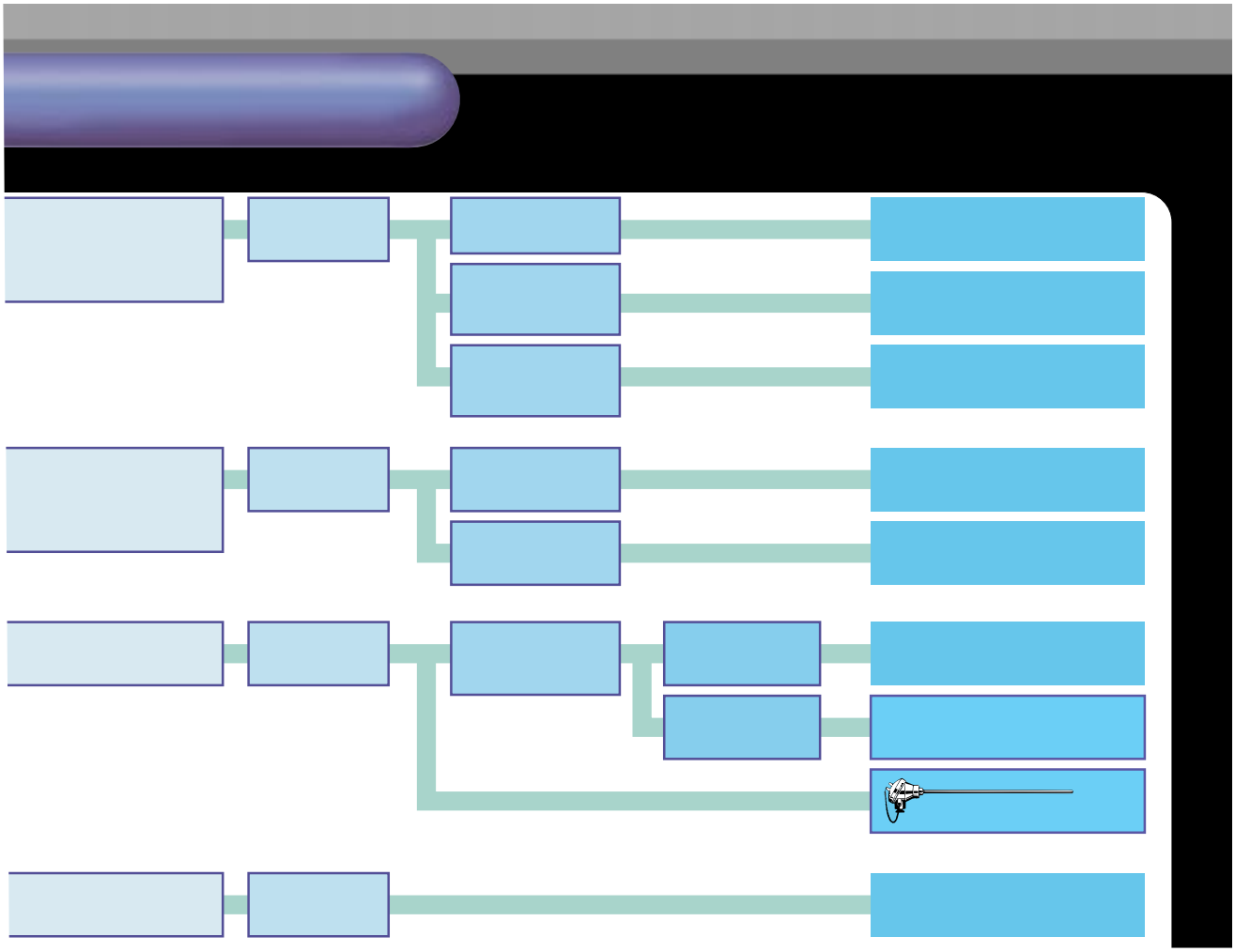
Using the E5ZN-SDL to set items that do not require setting with an operating panel eliminates the need for software to make and display multiple settings.



E5 N
E5CS
E5C2
E5L

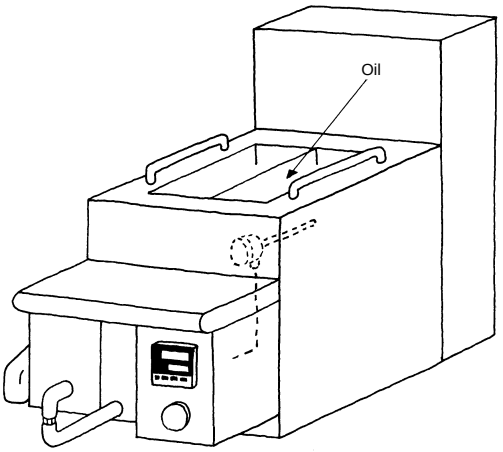



G32A



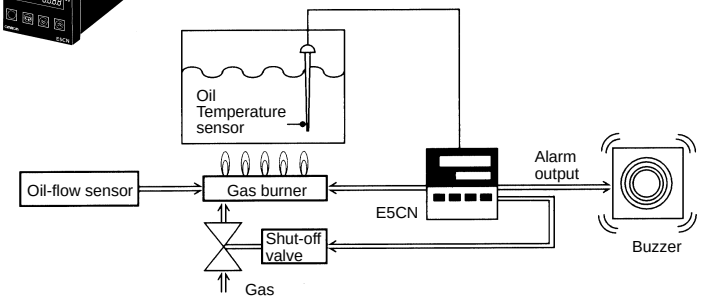
Applications

Fryer



E5CN

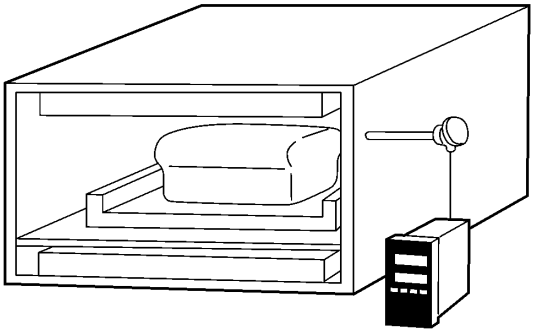
A low-cost Temperature Controller that has a process value display is required for the temperature control of a fryer.



Oil-flow sensor: The oil-flow sensor detects the flow of oil and shuts off the burner if there is a decrease in the quantity of oil flow.

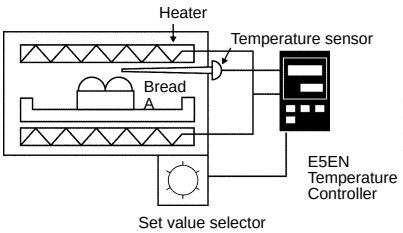
Temperature Controller: The Temperature Controller is in ON/OFF control of the oil temperature at 160°C. If the oil temperature exceeds 180°C, the alarm output turns ON, the buzzer goes off, and the valve is shut-off.

Rack-type Oven at a Bakery



E5EN

Changes in temperature setting are required for various types of bread.

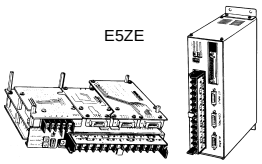


Example:
Set point 0 for bread A: 170°C
Set point 1 for bread B: 180°C
Set point 2 for bread C: 190°C
Set point 3 for bread D: 200°C
Max. 4 set points

Four set points can be stored in the memory of the E5EN, any of which can be selected with ease.

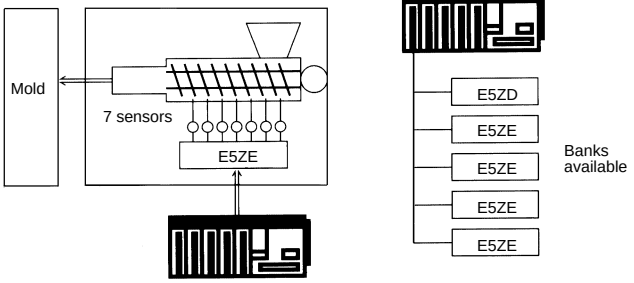
Injection Molding Machine

E5ZE



Changes in control temperature and PID constants are required for various types of products.

The control temperature and PID constants are selected according to the product type.



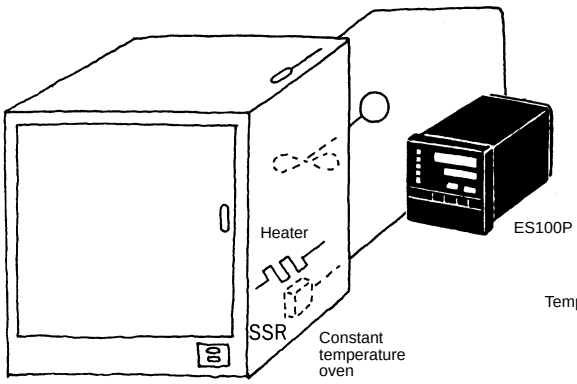
The bank is selected with the Programmable Controller.

The E5ZE is a multipoint, single-board Temperature Controller with 8 banks. Use the C200HX, C200HG, or C200HE Programmable Controller to select the data in each bank, such as control temperature and PID constant data for product control.

The SYSMAC C200HX, C200HG, and C200HE Programmable Controllers have a built-in protocol macro function.

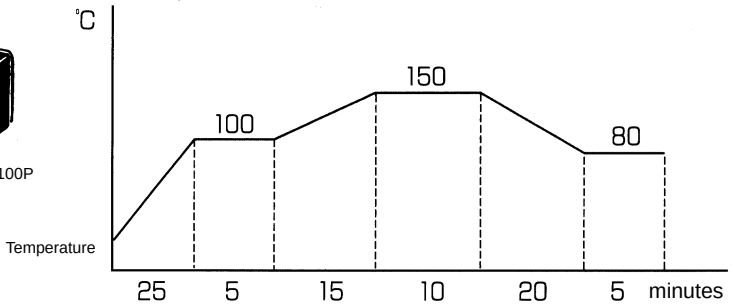
Applications

Constant Temperature Oven



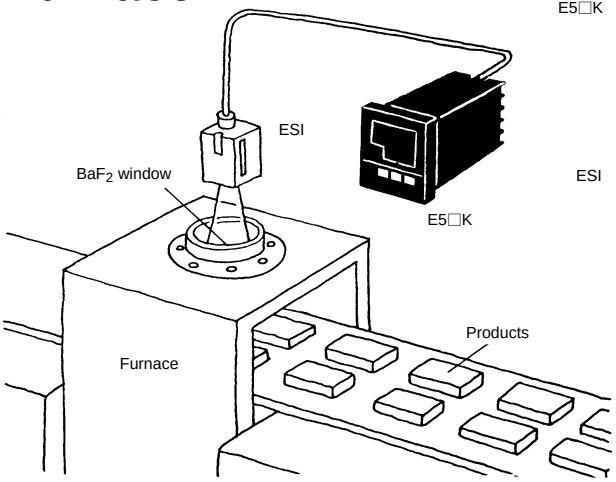
ES100P

Simple but precise temperature control is required for a constant temperature oven.



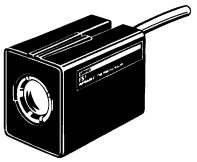
The temperature pattern is set in the ES100P Digital Controller operating with a start signal.

Furnace



E5□K

ESI



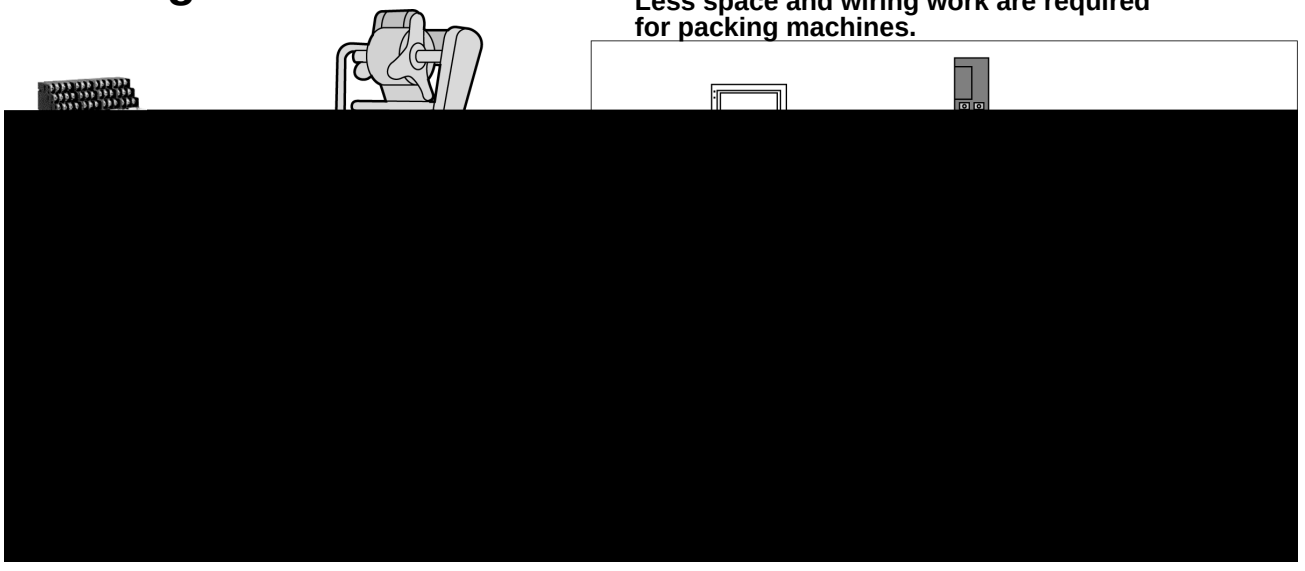
High-precision temperature control is required for a furnace.

The E5□K Digital Controller and the ES1 Non-contact Sensor are used in combination to check the temperature of the product for precise quality control.

The temperature of the processed products can be checked for precise quality control. Apply BaF_2 infrared-transparent material to the windows.

Packing Machine

Less space and wiring work are required for packing machines.



Applications

Serial Communications

Advantage

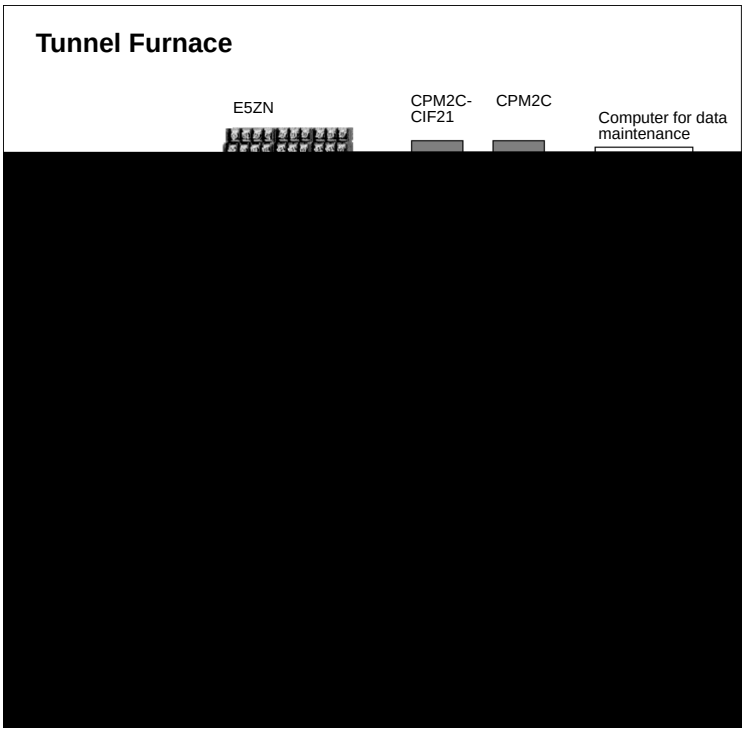
- Flexible expansion is possible in Unit–configured installations.
- Programming requirements can be reduced using the CPM2C–CIF21.
- Combining with a computer enables use of data logging and recipe functions.

Applications

- Baking furnace (tunnel furnace)

Explanation

- The temperature and conveyor control systems are separate.
- User maintenance is easy.



SP Ramp

Advantage

- Prevents workpieces from radical heating.

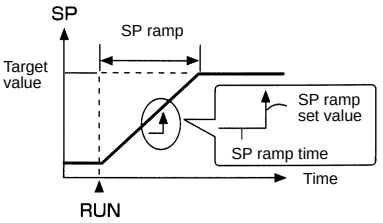
Applications

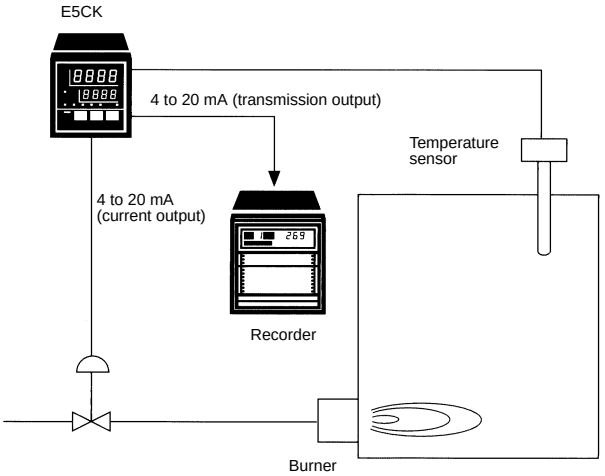
- Applications where the thermal shock is unfavorable.
- Simple program control

Explanation

- The ceramic baking furnace is in temperature control with a gas burner.
- A smooth temperature rise is required because the ceramic material may crack if there is a sudden temperature rise.

Ceramic Baking Furnace





Applications

Remote SP

Advantage

- Uses external 4- to 20-mA analog signals as SP values.

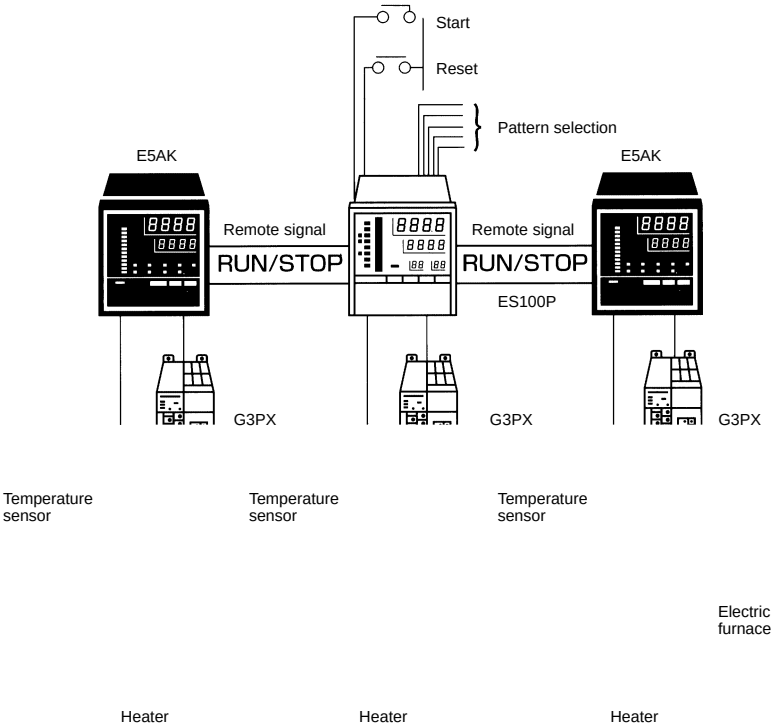
Applications

- Zone control of tunnel furnace

Explanation

- The electric furnace is in zone control using the remote SP function of the Digital Controllers.
- Three Digital Controllers are used to make the furnace temperature even.
- Selectable patterns are stored in the ES100P. The system is in operation with the start signal and according to the selected pattern.
- The remote SP function is in control of the three zones with the same pattern.

Tunnel Furnace (Electric Furnace)



Input Digital Filter

Advantage

- Smooths radical input changes.

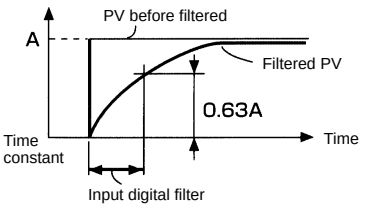
Applications

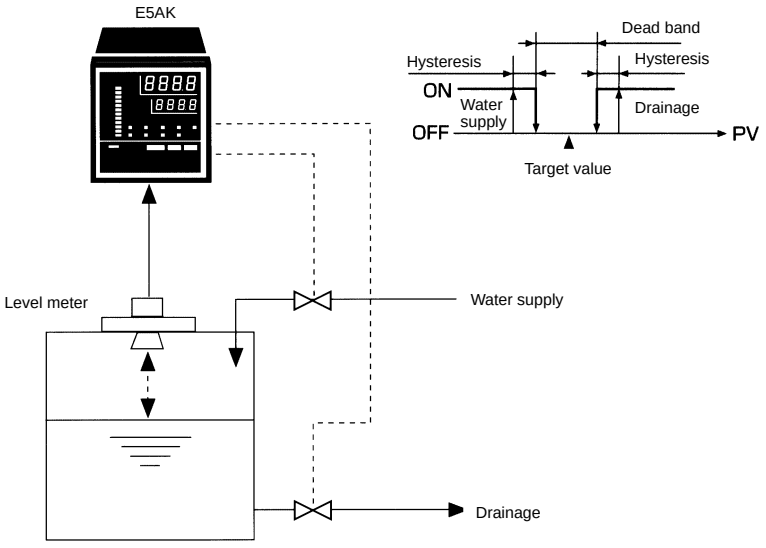
- Applications with quick thermal response, if the unstable process value unfavorably affects the control of the systems.
- A reduction in noise, if the noise unfavorably affects the process value.

Explanation

- The water level of the tank is checked with a supersonic level meter while the water supply and drain pumps are in ON/OFF control.
- The water surface undulates, thus making the process value (PV) unstable. Therefore, an input digital filter is applied to alleviate the fluttering of the process value.

Water Tank Level Control (3-position Control)





Selection Guide

E5□N

Use		General-purpose models	
Model type		Digital Temperature Controller	
Model		E5□N	E5CN-U
Item		Standard/Communications type	Plug-in
Size		96 x 96 E5AN 48 x 96 E5EN 48 x 48 E5CN 48 x 24 E5GN	48 x 48 E5CN-U
Control mode	**ON/OFF**	Yes	
	PID	---	
	2-PID	Yes	
Auto-tuning function		Yes	
Self-tuning function		Yes	
Hysteresis in ON/OFF control action		0.1 to 999.9 EU (in units of 0.1 EU)	
Indication accuracy		Thermocouple: (±0.5% of indicated value or ±1°C, whichever greater) ±1 digit max. (see note) Platinum resistance thermometer: (±0.5% of indicated value or ±1°C, whichever greater) ±1 digit max. Analog input: ±0.5% FS±1 digit max. CT input: ±5% FS±1 digit max.	Thermocouple: (±1% of indicated value or ±2°C, whichever greater) Platinum resistance thermocouple: (±0.5% of indicated value or ±1°C, whichever greater)
Input		Thermocouple: K, J, T, E, L, U, N, R, S, B Platinum resistance thermometer: Pt100, JPt100 Infrared temperature sensor: 10 to 70°C, 60 to 120°C, 115 to 165°C, 160 to 260°C Voltage input: 0 to 50 mV	
Output		Relay, voltage, and current output (E5GN: Relay, voltage)	Relay, voltage
Heater burnout (not used with current output)		Yes (E5AN, E5EN, E5CN)	---
Communication		RS-232C (E5AN/E5EN), RS-485 (E5AN/E5EN/E5CN/E5GN)	---
Supply voltage		100 to 240 VAC or 24 VAC/DC	
Terminal configuration		Screw terminals	Plug-in
EMC		Conforms to EN55011 Group 1 class A, EN55011 Group 1 class A, EN61000-4-2, ENV50140, ENV50141, EN61000-4-4	
Approved standards		UL, CSA	
Datasheet Cat. No.		H107: E5AN/EN/CN/GN Datasheet	H109: E5CN-U Datasheet
Manual Cat. No.		H100: E5CN User's Manual H101: E5GN User's Manual H111: E5EN User's Manual H112: E5AN User's Manual H102: E5AN/EN/CN/GN Communication Manual	

Note: This page provides information on main specifications only. Be sure to read the information on detailed specifications and precautions before using the models listed here.

Selection Guide

E5□K

Use		General-purpose models			
Model type		Digital Process Controller			
Model		E5□K		E5AK/E5EK	
Function		Standard		Position proportional	
Item		Standard type	Communications type	Standard type	Communications type
Size		96 x 96 / 48 x 96 / 53 x 53 E5AK / E5EK / E5CK	96 x 96 / 48 x 96 / 53 x 53 E5AK / E5EK / E5CK	96 x 96 / 48 x 96 E5AK / E5EK	96 x 96 / 48 x 96 E5AK / E5EK
Control mode	**ON/OFF**	Yes			
	PID	---			
	2-PID	Yes			
	PID with fuzzy control	---			
Auto-tuning function		Yes			
Self-tuning function		Yes			
Hysteresis in ON/OFF control action		0.01% to 99.99% FS (in units of 0.01%)			
Indication accuracy		Thermocouple: (±0.3% of indicated value or ±1°C, whichever greater) ±1 digit max. Platinum resistance thermometer: (±0.2% of indicated value or ±0.8°C, whichever greater) ±1 digit max. Analog input: ±0.2% FS ±1 digit max.			
Input		K, J, T, L, U, N, R, S, B, W, PLII, JPt100, or PT100 Current or voltage input			
Output (Optional)		Relay, SSR, voltage, linear voltage, and linear current output		Relay output	
Heater burnout (not used with current output)		Yes (E5AK/E5EK) Loop burnout alarm is available (E5AN/E5EK/E5CK)		---	
Communication		RS-232C, RS-422, RS-485			
Supply voltage		100 to 240 VAC or 24 VAC/DC at 50/60 Hz			
Terminal configuration		Screw terminals			
EMC		Conforms to EN50081-2, EN50082-2			
Approved standards		UL, CSA			
Datasheet Cat. No.		H084: E5AK/EK Digital Controller DS H079: E5CK Digital Controller Cat.			
Manual Cat. No.		H083: E5AK User's Manual H085: E5EK User's Manual H078: E5CK User's Manual			

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Selection Guide

E5□K-T Programmable Type

Use		General-purpose models			
Model type		Digital Process Controller			
Model		E5□K-T programmable type			
Function		Standard		Position proportional	
Item		Standard type	Communications type	Standard type	Communications type
Size		96 x 96 48 x 96 53 x 53 E5AK-TA E5EK-TA E5CK-TA	96 x 96 48 x 96 53 x 53 E5AK-TA E5EK-TA E5CK-TA	96 x 96 48 x 96 E5AK-TA E5EK-TA	96 x 96 48 x 96 E5AK-TA E5EK-TA
Control mode	**ON/OFF**	Yes			
	PID	---			
	2-PID	Yes			
	PID with fuzzy control	---			
Auto-tuning function		Yes			
Self-tuning function		Yes			
Hysteresis in ON/OFF control action		0.01% to 99.99% FS (in units of 0.01%)			
Indication accuracy		Thermocouple: (±0.3% of indicated value or ±1°C, whichever greater) ±1 digit max. Platinum resistance thermometer: (±0.2% of indicated value or ±0.8°C, whichever greater) ±1 digit max. Analog input: ±0.2% FS ±1 digit max.			
Input		K, J, T, L, U, N, R, S, B, W, PLII, JPt100, or PT100 Current or voltage input			
Output (Optional)		Relay, SSR, voltage, linear voltage, and linear current output		Relay output	
Heater burnout (not used with current output)		Yes (E5AK/E5EK) Loop burnout alarm is available (E5AN/E5EK/E5CK)		---	
Communication		RS-232C, RS-422, RS-485			
Supply voltage		100 to 240 VAC or 24 VAC/DC at 50/60 Hz			
Terminal configuration		Screw terminals			
EMC		Conforms to EN50081-2, EN50082-2			
Approved standards		UL, CSA			
Datasheet Cat. No.		H087: E5□K-T Digital Controller DS			
Manual Cat. No.		H088: E5AK User's Manual (Programmable Type) H089: E5EK User's Manual (Programmable Type) H090: E5CK User's Manual (Programmable Type)			

Note: This page provides information on main specifications only. Be sure to read the information on detailed specifications and precautions before using the models listed here.

Selection Guide

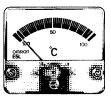
E5CS

Use		General-purpose models	
Model type		Digital Temperature Controller	
Model		E5CS	E5CS-X
Item		Plug-in	Basic
Size		48 x 48	48 x 48
Control mode	ON/OFF	Yes	
	PID	Yes	
	2-PID	---	
	PID with fuzzy control	---	
Auto-tuning function		---	
Self-tuning function		Yes	
Hysteresis in ON/OFF control action		0.2% FS fixed	
Indication accuracy		±1% FS ± 1 digit max.	±0.5% FS ± 1 digit max.
Input		K, J, L, JPt100, Pt100 or thermistor	
Output		Relay or voltage output	
Supply voltage		100 to 240 VAC or 24 VAC/VDC at 50/60 Hz	
Terminal configuration		Plug-in model	Screw terminals
EMC		Conforms to EN50081-2, EN50082-2	
Approved standards		UL, CSA	
Datasheet Cat. No.		H042	H032

Note: This page provides information on main specifications only. Be sure to read the information on detailed specifications and precautions before using the models listed here.

Selection Guide

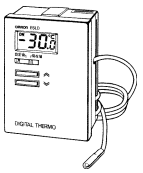
E5C2, E5L

Use		General-purpose models	
Model type		Analog Temperature Controller	Digital Thermometer
Model		E5C2	E5L
Item		Basic	Basic
Size		48 x 48	Digital Thermometer (with external setting device) External setting device  Panel meter
Control mode	**ON/OFF**	Yes	
	PID	P action	---
	2-PID	---	
	PID with fuzzy control	---	
Auto-tuning function		---	
Self-tuning function		---	
Hysteresis in ON/OFF control action		0.5% FS fixed	Variable
Indication accuracy		±2% FS max.	±2% FS max.
Input		K, J, JPt100, and THE	THE (element-compatible thermistor)
Output		Relay output	
Supply voltage		100/110, 200/220 VAC at 50/60 Hz	100, 110, 200, 220 (individual) VAC at 50/60 Hz (common)
Terminal configuration		Plug-in model	
EMC		Conforms to EN50081-2, EN50082-2	---
Approved standards		UL, CSA	---
Datasheet Cat. No.		H081	H020

Note: This page provides information on main specifications only. Be sure to read the information on detailed specifications and precautions before using the models listed here.

Selection Guide

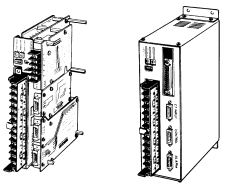
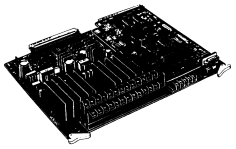
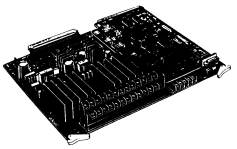
E5LC, E5LD

Use		Economy models	
Model type		Temperature Display	Digital Thermometer
Model		E5LC	E5LD
Item		Temperature display only	ON/OFF control type
Size			
Control mode	**ON/OFF**	---	Yes
	PID	---	
	2-PID	---	
	PID with fuzzy control	---	
Auto-tuning function		---	
Self-tuning function		---	
Hysteresis in ON/OFF control action		---	0.5 to 9.0°C (in units of 0.5°C)
Setting accuracy		---	±1°C + 1 digit max.
Indication accuracy		±1°C ± 1 digit max.	
Input		Mono-block thermistor	
Output		---	Relay
Heater burnout (not used with current output)		---	
Supply voltage		---	100, 200 VAC (depends on model) at 50/60 Hz (common)
Terminal configuration		---	Screw terminals
EMC		Conforms to EN50081-2, EN50082-2	---
Approved standards		---	
Datasheet Cat. No.		H035	

Note: This page provides information on main specifications only. Be sure to read the information on detailed specifications and precautions before using the models listed here.

Selection Guide

E5ZE, E5ZD

Use		Multipoint control models		
Model type		Multipoint Temperature Controller		
Model		E5ZE	E5ZD	E5ZD-8F
Item		---		
Size				
Control mode	**ON/OFF**	Yes		
	PID	---		
	2-PID	---	Yes	---
	PID with fuzzy control	Yes	---	Yes
Auto-tuning function		Yes		
Self-tuning function		---		
Hysteresis in ON/OFF control action		0.0 to 99.9°C/°F for ON/OFF control only (in units of 0.1°C/°F)		
Indication accuracy		Thermocouple: ±0.3% or ±2°C of indicated value (whichever is larger) ± 1 digit max. Platinum resistance thermometer: ±0.3% or ±0.8°C (whichever is larger) ± 1 digit max.	±0.5% FS ± 1 digit max.	
Input		K, J, R, S, T, E, B, N, L, U, W/Re5-26, PT II, Pt100, or JPt100	K, J, JPt100, or Pt100	
Output		Voltage or current output	Voltage or open collector output	
Heater burnout (not used with current output)		Yes		
Supply voltage		24 VDC		
Terminal configuration		Screw terminals	Dedicated terminal	
EMC		Conforms to EN50081-2, EN50082-2	---	
Approved standards		---		
Datasheet Cat. No.		H075	H060	
Manual Cat. No.		H077: E5ZE Communications Manual H076: E5ZE Operation Manual	Z042: E5ZD Operation Manual (European Version) Z084: E5ZD-□V Operation Manual (European Version)	

Note: This page provides information on main specifications only. Be sure to read the information on detailed specifications and precautions before using the models listed here.

Selection Guide

E5ZN

Use		Din track mounting models
Model type		Module Temperature Controller
Model		E5ZN
Item		Communications type
Size		(Terminal Unit sold separately) Setting display
Control mode	**ON/OFF**	Yes
	PID	---
	2-PID	Yes
Auto-tuning function		
Self-tuning function		---
Hysteresis in ON/OFF control action		0.1 to 999 EU (in units of 0.1 EU)
Indication accuracy		Thermocouple: (±0.5% of indicated value or ±1°C, whichever greater) ±1 digit max. Platinum resistance thermometer: (±0.5% of indicated value or ±1°C, whichever greater) ±1 digit max. Analog input: ±0.5% FS ±1 digit max.
Input		Thermocouple: K, J, T, E, L, U, N, R, S, B Infrared temperature sensor: ES1A series Voltage input: 0 to 50 mV Platinum resistance thermometer: Pt100, JPt100
Output		Voltage, transistor, or current output
Heater burnout (not used with current output)		Yes
Supply voltage		24 VAC/DC
Terminal configuration		Screw terminal (Terminal Unit sold separately)
EMC		EN61326
Approved standards		UL, CSA
Datasheet Cat. No.		H116
Manual Cat. No.		H113

Note: This page provides information on main specifications only. Be sure to read the information on detailed specifications and precautions before using the models listed here.

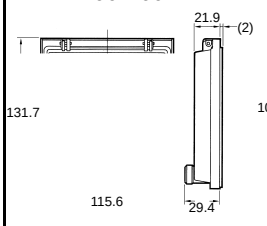
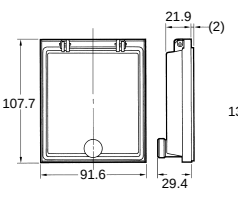
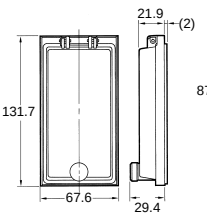
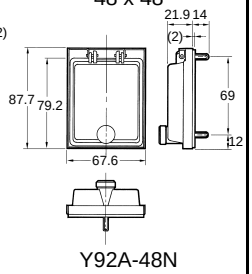
Selection Guide

ES100

Use		Current and voltage input models
Model type		Process Controller
Model		ES100X, ES100P
Item		Digital Controller
Size		96 x 96 ES100X (fixed value type) 96 x 96 ES100P (programmable type)
Control mode	**ON/OFF**	Yes
	PID	---
	2-PID	Yes
	PID with fuzzy control	Yes
Auto-tuning function		Yes
Self-tuning function		---
Hysteresis in ON/OFF control action		0.01% to 99.99% FS in 0.01% FS increments
Indication accuracy		±0.1% FS ± 1 digit max.
Input		K, J, T, E, R, S, B, N, L, U, PL II, W, Pt100, or JPt100 voltage or current input
Output		Output Unit available to relay, SSR, voltage, and current output.
Heater burnout (not used with current output)		Yes
Supply voltage		100 to 240 VAC 50/50 Hz
Terminal configuration		Screw terminals
EMC		---
Approved standards		UL, CSA
Datasheet Cat. No.		H058
Manual Cat. No.		H072: ES100 Communications Guide H069: ES100P Digital Controller Programmer User's Guide H115: ES100 Support Software ES/TOOLS for Windows Operation Manual H070: ES100X Digital Controller User's Manual

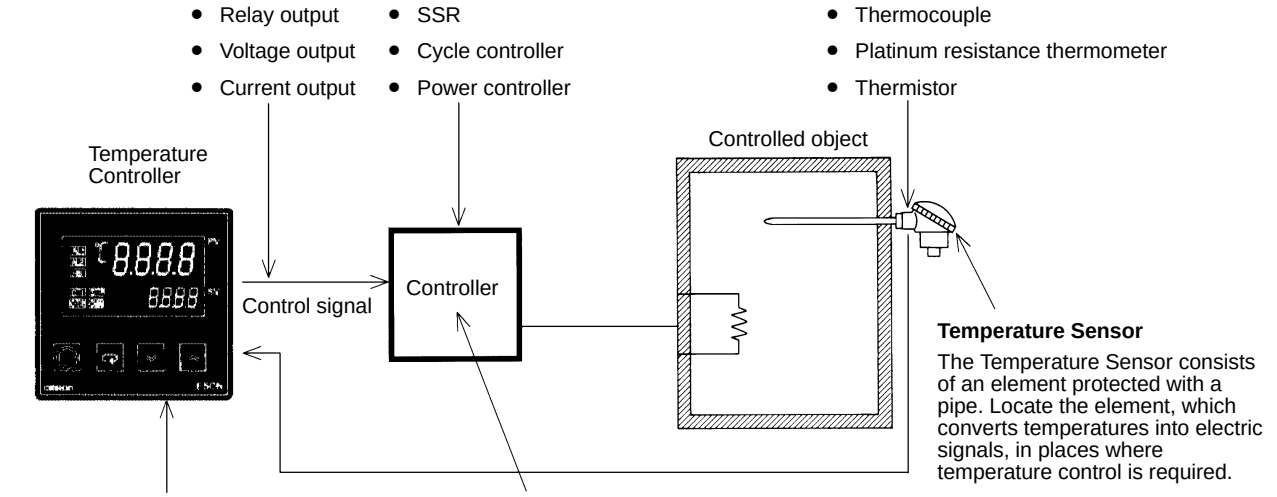
Note: This page provides information on main specifications only. Be sure to read the information on detailed specifications and precautions before using the models listed here.

Watertight Covers

Model	Y92A-□□
Size	96 x 96  Y92A-96N 72 x 72  Y92A-72N 48 x 96  Y92A-49N 48 x 48  Y92A-48N
Degree of protection	IP66 or NEMA4 (indoors)
Datasheet Cat. No.	Q088

Configuration Example of Temperature Control

The following is an example of the configuration of temperature control.



Temperature Sensor

The Temperature Sensor consists of an element protected with a pipe. Locate the element, which converts temperatures into electric signals, in places where temperature control is required.

Electronic Temperature Controller

The Electronic Temperature Controller is a product that receives electric signal input from the temperature sensor, compares the electric signal input with the set point, and outputs adjustment signals to the Controller.

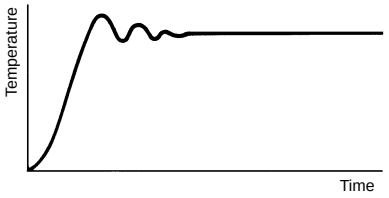
Controller

The Controller is used to heat up or cool down furnaces and tubs using a device, such as a solenoid or fuel valve, to switch electric currents supplied to heaters or coolers.

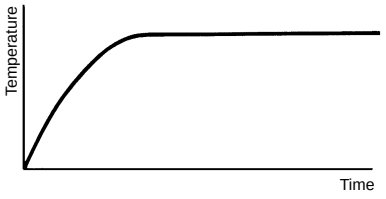
Temperature Control

The set point is input into the Temperature Controller in order to operate the Temperature Controller. The time required for stable temperature control varies with the controlled object. Attempting to shorten the response time will usually result in the overshooting or hunting of temperature. When reduce the overshooting or hunting of temperature, the response time must not be shortened. There are applications that require prompt, stable control in the waveform shown in (1) despite overshooting. There are other applications that require the suppression of overshooting in the waveform shown in (3) despite the long time required to stabilize temperature. In other words, the type of temperature control varies with the application and purpose. The waveform shown in (2) is considered to be a proper one for standard applications.

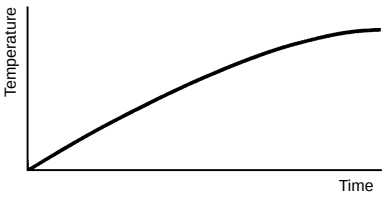
1. The temperature stabilizes after overshooting several times.



2. Proper response



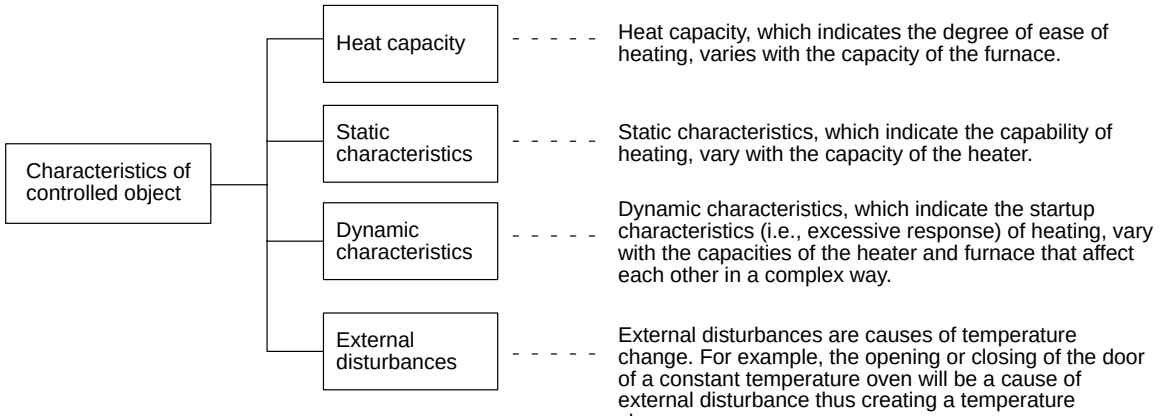
3. The response is slow in reaching the set point.



Technical Information

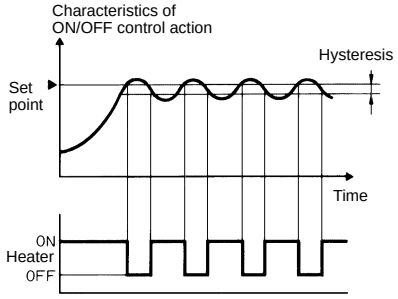
Characteristics of the Controlled Object

Before selecting the Temperature Controller and Temperature Sensor models, it is necessary to understand the thermal characteristics of the controlled object for proper temperature control.


Characteristics of controlled object
Heat capacity
Heat capacity, which indicates the degree of ease of heating, varies with the capacity of the furnace.
Static characteristics
Static characteristics, which indicate the capability of heating, vary with the capacity of the heater.
Dynamic characteristics
Dynamic characteristics, which indicate the startup characteristics (i.e., excessive response) of heating, vary with the capacities of the heater and furnace that affect each other in a complex way.
External disturbances
External disturbances are causes of temperature change. For example, the opening or closing of the door of a constant temperature oven will be a cause of external disturbance thus creating a temperature change.

■ ON/OFF Control Action

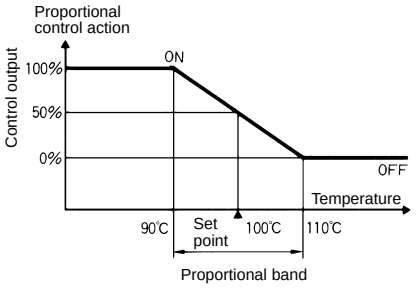
As shown in the graph below, if the process value is lower than the set point, the output will be turned ON and power will be supplied to the heater. If the process value is higher than the set point, the output will be turned OFF with power to the heater shut off. This control method is called ON/OFF control action, in which the output is turned ON and OFF on the basis of the set point to keep the temperature constant. In this operation, the temperature is controlled with two values (i.e., 0% and 100% of the set point). Therefore, the operation is also called two-position control action.



■ P Action

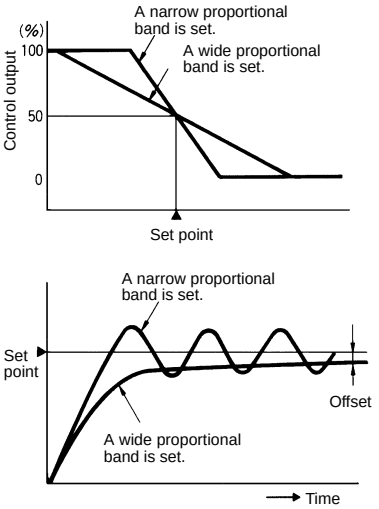
P action (or proportional control action) is used for obtaining the output in proportion to the input.

The Temperature Controller in P action has a proportional band with the set point in the proportional band. The control output varies in proportion to the deviation in the proportional band. In normal operation, a 100% control output will be ON if the process value is lower than the proportional band. The control output will be decreased gradually in proportion to the deviation if the process value is within the proportional band, and a 50% control output will be ON if the set point coincides with the process value (i.e., there is no deviation). This means P action ensures smooth control with minimal hunting compared with the ON/OFF control action.



Example:

If a Temperature Controller with a temperature range of 0° to 400°C has a 5% proportional band, the width of the proportional band will be converted into a temperature range of 20°C. In this case, provided that the set point is 100°C, a full output is kept turned ON until the process value reaches 90°C, and the output is OFF periodically when the process value exceeds 90°C. When the process value is 100°C, there will be no difference in time between the ON period and the OFF period (i.e., the output is turned ON and OFF with the same interval).

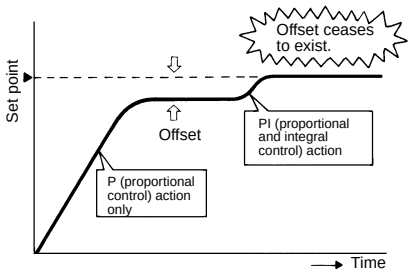


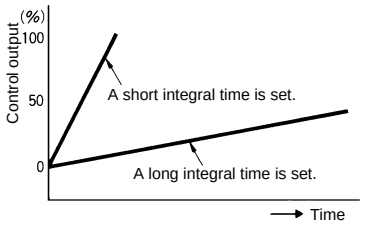
Technical Information

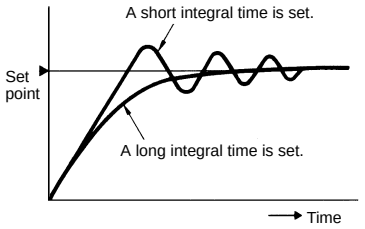
■ I Action

I action (or integral control action) is used for obtaining the output in proportion to the time integral value of the input.

P action causes an offset. Therefore, if proportional control action and integral control action are used in combination, the offset will be reduced as the time goes by until finally the control temperature will coincide with the set point and the offset will cease to exist.



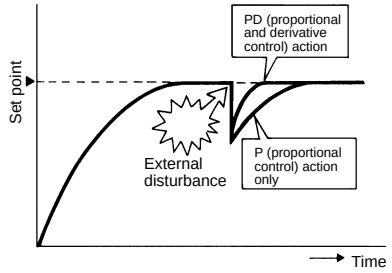


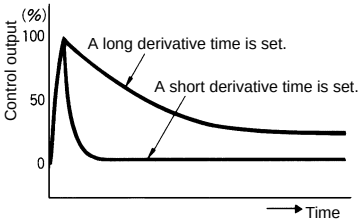


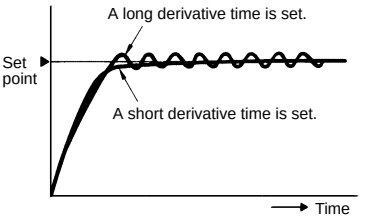
■ D Action

D action (or derivative control action) is used for obtaining the output in proportion to the time derivative value of the input.

Proportional control action corrects the result of control and so does integral control action. Therefore, proportional control action and integral control action respond slowly to temperature change, which is why derivative control action is required. Derivative control action corrects the result of control by adding the control output in proportion to the slope of temperature change. A large quantity of control output is added for a radical external disturbance so that the temperature can be quickly in control.

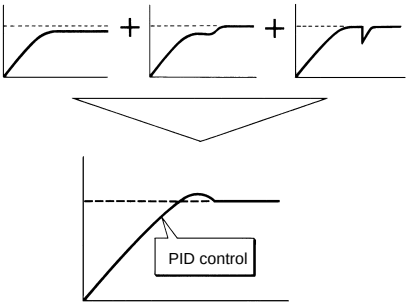






■ PID Control

PID control is a combination of proportional, integral, and derivative control actions, in which the temperature is controlled smoothly by proportional control action without hunting, automatic offset adjustment is made by integral control action, and quick response to an external disturbance is made possible by derivative control action.

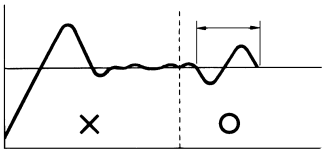


Technical Information

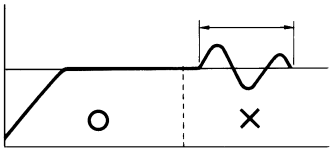
■ 2-PID Control

Conventional PID control uses a single control block to control the responses of the Temperature Controller to a target value and external disturbances. Therefore, the response to the target value will oscillate due to overshooting if importance is attached to the response to external disturbances with the P and I parameters set to small values and the D parameter set to a large value in the control block. On the other hand, if importance is attached to the response to the target value (i.e., the P and I parameters are set to large values), the Temperature Controller will not be able to respond to external disturbances quickly. It will be impossible to satisfy both the types of responses in this case.
2-PID control eliminates this weakness while retaining the strengths of PID control, thus making it possible to improve both types of responses.

PID Control

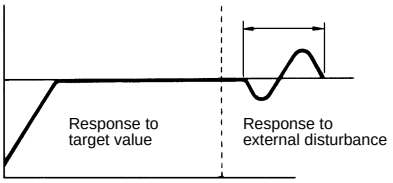


Response to the target value will become slow if response to the external disturbance is improved.



Response to the external disturbance will become slow if response to the target value is improved.

2-PID Control

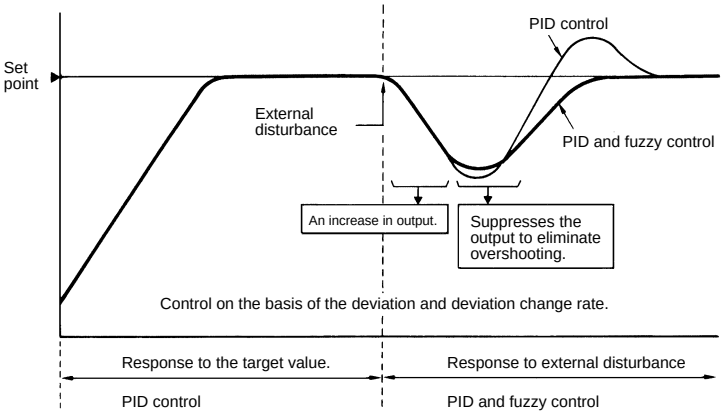


Controls both the target value response and external disturbance response.

■ PID with Fuzzy Control

By adding fuzzy control to PID control, further improvement in response to external disturbances is possible. PID and fuzzy control usually operate as PID control. If there is external disturbance, fuzzy control will operate in combination with PID control.

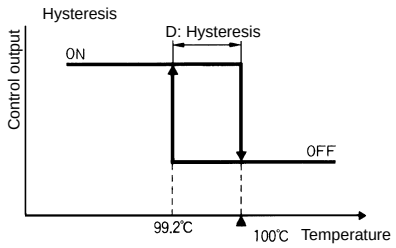
OMRON's fuzzy control estimates temperature change from the difference between the deviation (i.e., the difference between the set point and process value) and deviation change rate, and then makes the delicate adjustment of the control output.


PID control
Set point
External disturbance
PID and fuzzy control
An increase in output.
Suppresses the output to eliminate overshooting.
Control on the basis of the deviation and deviation change rate.
Response to the target value.
Response to external disturbance
PID control
PID and fuzzy control

Control

Hysteresis

ON/OFF control action turns the output ON or OFF on the basis of the set point. This means the output frequently changes according to minute temperature changes, which shortens the life of the output relay or unfavorably affects some devices connected to the Temperature Controller. Therefore, a margin is prepared between the ON and OFF operations. This margin is called hysteresis.

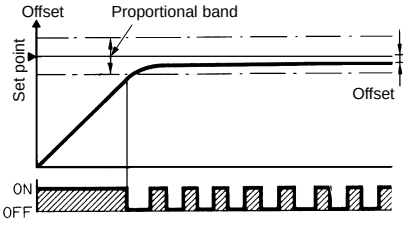


Example:

If the Temperature Controller with a temperature range of 0°C to 400°C has a 0.2% hysteresis, D will be 0.8°C. Therefore if the set point is 100°C, the output will turn OFF at a process value of 100°C and will turn ON at a process value of 99.2°C.

Offset

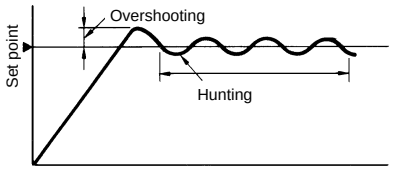
Proportional control action causes an error in the process value due to the heat capacity of the controlled object and the capacity of the heater, which results in a small discrepancy between the process value and set point in stable operation. This error is called offset. Offset may exist above or below the set point.



Hunting and Overshooting

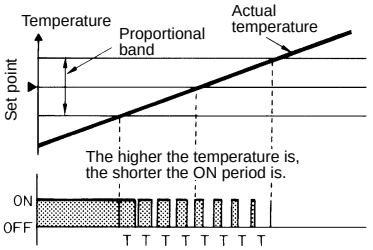
ON/OFF control action often involves the waveform shown in the following graph. A temperature rise in excess of the set point after temperature control starts is called overshooting. Temperature oscillation near the set point is called hunting. Improved temperature control is to be expected if the degrees of overshooting and hunting are low.

Hunting and Overshooting in ON/OFF Control Action



Control Cycle and Time-proportioning Control Action

The control output will be turned ON intermittently according to a preset cycle if P action is used with a relay or SSR. This preset cycle is called control cycle and this control method is called time-proportioning control action.



T: Control cycle

$$\text{Control output} = \frac{T_{ON}}{T_{ON} + T_{OFF}} \times 100\ (\%)$$

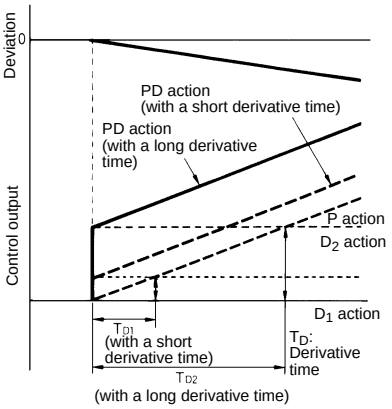
T_{ON}: ON period
T_{OFF}: OFF period

Example;
If the control cycle is 10 s with an 80% control output, the ON and OFF periods will be the following values.
T_{ON}: 8 s
T_{OFF}: 2 s

Derivative Time

Derivative time is the period required for a ramp-type deviation in derivative control (e.g., the deviation shown in the following graph) to coincide with the control output in proportional control action. The longer the derivative time is, the stronger the derivative control action is.

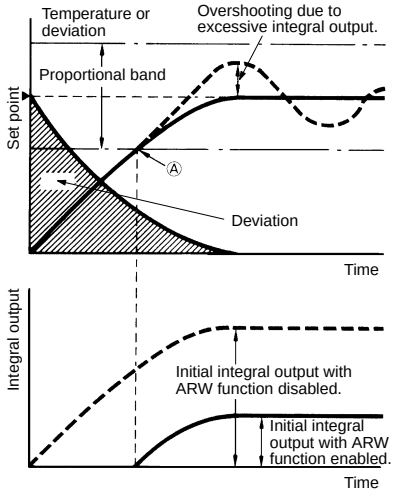
PD Action and Derivative Time



Glossary

ARW Function

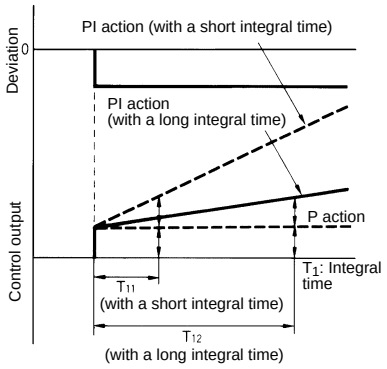
ARW stands for anti-reset windup.
There is usually a large deviation (i.e., a large difference between the process value and set point) when the Temperature Controller starts operating. Integral control action in PID control is repeated until the temperature reaches the set point. As a result, an excessive integral output causing overshooting is output. To prevent this, the ARW function sets a limit to restrict the output rise in integral control action. In normal control operation, the integral output is eliminated until the process value reaches the proportional band.



Integral Time

Integral time is the period required for a step-type deviation in integral control (e.g., the deviation shown in the following graph) to coincide with the control output in proportional control action. The shorter the integral time is, the stronger the integral control action is. If the integral time is too short, however, hunting may result.

PI Action and Integral Time

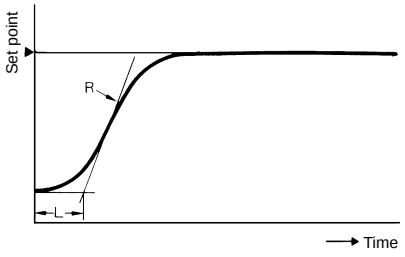


■ Auto-tuning

PID constants for temperature control vary in value and combination according to the characteristics of the controlled object. There has been a variety of conventional methods suggested and implemented to obtain PID constants from the waveforms of temperatures to be controlled by the Temperature Controller in actual operation. Among them, auto-tuning methods make it possible to obtain PID constants suitable to a variety of objects. Auto-tuning methods include the step response, marginal sensitivity, and limit cycle methods.

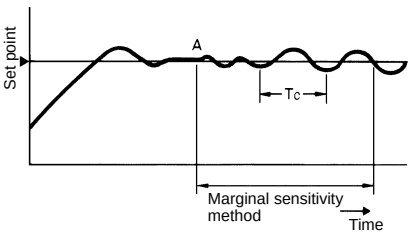
Step Response Method

The value most frequently used must be the set point in this method. Calculate the maximum temperature ramp R and the dead time L from a 100% step-type control output. Then obtain the PID constants from R and L.



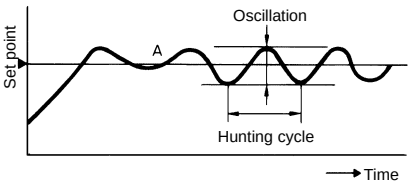
Marginal Sensitivity Method

Proportional control action starts from the start point A in this method. Narrow the width of the proportional band until the temperature starts to oscillate. Then obtain the PID constants from the value of the proportional band and the oscillation cycle T at that time.



Limit Cycle Method

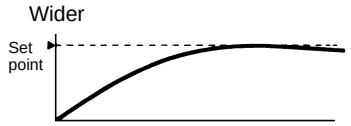
ON/OFF control action starts from the start point A in this method. Then obtain the PID constants from the hunting cycle T and oscillation D.



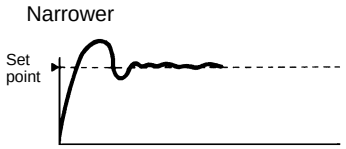
Readjustment of PID Constants

PID constants calculated in auto-tuning operation normally do not cause problems except for some particular applications, in which case, refer to the following to readjust the PID constants.

Response to Change in Proportional Band

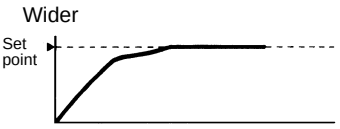


It is possible to suppress overshooting although a comparatively long startup time and set time will be required.

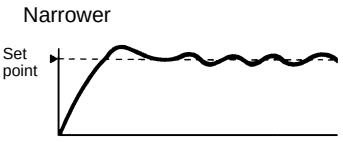


The process value reaches the set point within a comparatively short time and keeps the temperature stable although overshooting and hunting will result until the temperature becomes stable.

Response to Change in Integral Time

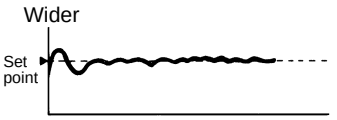


It is possible to reduce hunting, overshooting, and undershooting although a comparatively long startup time and set time will be required.

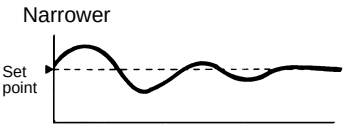


The process temperature reaches the set point within a comparatively short time although overshooting, undershooting, and hunting will result.

Response to Change in Derivative Time



The process value reaches the set point within a comparatively short time with comparatively small amounts of overshooting and undershooting although fine-cycle hunting will result due to the change in process value.



It will take a comparatively long time for the process value to reach the set point with heavy overshooting and undershooting.

■ Fuzzy Self-tuning

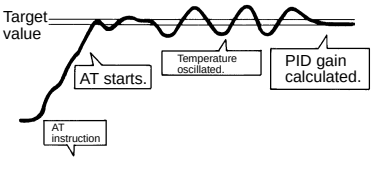
PID constants must be determined according to the controlled object for proper temperature control. The conventional Temperature Controller incorporates an auto-tuning function to calculate PID constants, in which case, it will be necessary to give instructions to the Temperature Controller to trigger the auto-tuning function. Furthermore, if the limit cycle method is adopted, temperature disturbance may result. The Temperature Controller in fuzzy self-tuning operation determines the start of tuning and ensures smooth tuning without disturbing temperature control. In other words, the fuzzy self-tuning function makes it possible to adjust PID constants according to the characteristics of the controlled object.

Fuzzy Self-tuning in 3 Modes

- PID constants are calculated by tuning at the time of change in the set point.
- When an external disturbance affects the process value, the PID constants will be adjusted and kept in a specified range.
- If hunting results, the PID constants will be adjusted to suppress the hunting.

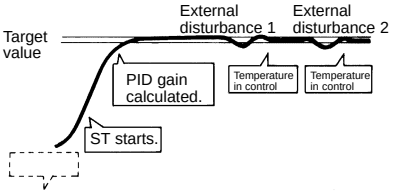
Auto-tuning Method of a Conventional Temperature Controller
Auto-tuning Function: Automatically calculates the appropriate PID constant for controlling objects.

Features:
1. Tuning will be performed when the AT instruction is given.
2. The limit cycle signal is generated to oscillate the temperature before tuning.



Self-tuning Function
Self-tuning (ST) Function: A function to automatically calculate optimum PID constants for controlled objects.

Features:
1. Whether to perform tuning or not is determined by the Temperature Controller.
2. No signal disturbing the process value is generated.

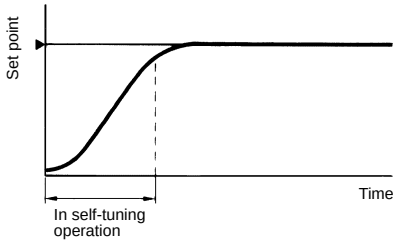


Glossary

■ Self-tuning Function

(Applicable Model: E5CS)

The self-tuning function is incorporated by E5CS Digital Temperature Controller. The function makes it possible to calculate and use an optimum proportional band automatically according to change in the temperature.

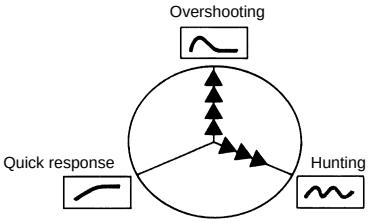


■ Fine-tuning Function

(Applicable Models: ES100X, ES100P)

The fine-tuning function is incorporated by the ES100 Digital Controller. Tuning is a delicate and troublesome job. The fine-tuning function performs fuzzy logic calculations to adjust the PID constants after the degrees of requirements for suppressing overshooting and hunting and improvements in response are set.

Setting of Fine-tuning Requirements

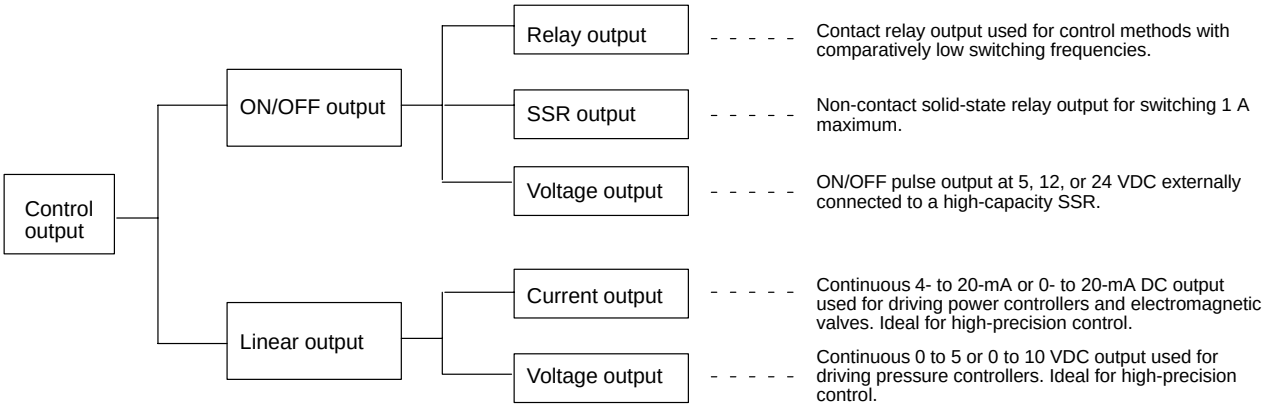


PID Control and Tuning Methods

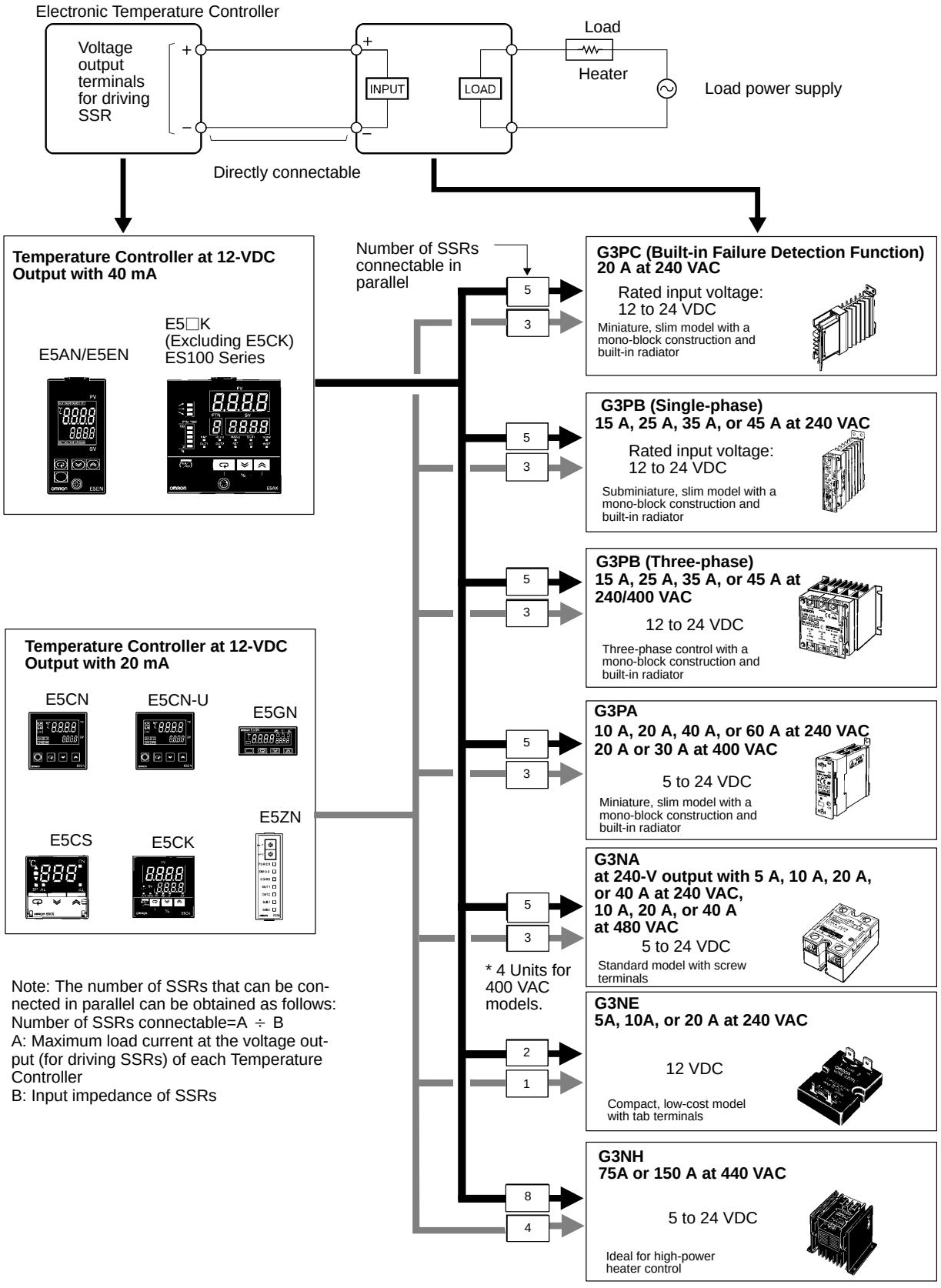
Model	Type of PID control		
	PID	2-PID	PID with fuzzy control
E5□N		AT, ST	
E5□K		AT, ST	
E5CS	ST*		
E5ZD		AT	AT
E5ZE			AT
ES100X			AT, FT
ES100P			AT. FT

Note: ST stands for fuzzy self-tuning function, ST* stands for self-tuning function, FT stands for fine-tuning function, and AT stands for auto-tuning function.

■ Control Output


Control output
ON/OFF output
Linear output
Relay output
SSR output
Voltage output
Current output
Voltage output
Contact relay output used for control methods with comparatively low switching frequencies.
Non-contact solid-state relay output for switching 1 A maximum.
ON/OFF pulse output at 5, 12, or 24 VDC externally connected to a high-capacity SSR.
Continuous 4- to 20-mA or 0- to 20-mA DC output used for driving power controllers and electromagnetic valves. Ideal for high-precision control.
Continuous 0 to 5 or 0 to 10 VDC output used for driving pressure controllers. Ideal for high-precision control.

Connection Example of Temperature Controller and SSR


Electronic Temperature Controller
Voltage output terminals for driving SSR
+
–
INPUT
LOAD
Load
Heater
Load power supply
Directly connectable
Temperature Controller at 12-VDC Output with 40 mA
E5AN/E5EN
E5□K (Excluding E5CK) ES100 Series
Temperature Controller at 12-VDC Output with 20 mA
E5CN
E5CN-U
E5GN
E5ZN
E5CS
E5CK
Number of SSRs connectable in parallel
5
3
G3PC (Built-in Failure Detection Function)
20 A at 240 VAC
Rated input voltage: 12 to 24 VDC
Miniature, slim model with a mono-block construction and built-in radiator
G3PB (Single-phase)
15 A, 25 A, 35 A, or 45 A at 240 VAC
Rated input voltage: 12 to 24 VDC
Subminiature, slim model with a mono-block construction and built-in radiator
G3PB (Three-phase)
15 A, 25 A, 35 A, or 45 A at 240/400 VAC
12 to 24 VDC
Three-phase control with a mono-block construction and built-in radiator
G3PA
10 A, 20 A, 40 A, or 60 A at 240 VAC
20 A or 30 A at 400 VAC
5 to 24 VDC
Miniature, slim model with a mono-block construction and built-in radiator
G3NA
at 240-V output with 5 A, 10 A, 20 A, or 40 A at 240 VAC,
10 A, 20 A, or 40 A at 480 VAC
5 to 24 VDC
Standard model with screw terminals
* 4 Units for 400 VAC models.
G3NE
5A, 10A, or 20 A at 240 VAC
12 VDC
Compact, low-cost model with tab terminals
2
1
G3NH
75A or 150 A at 440 VAC
5 to 24 VDC
Ideal for high-power heater control
8
4

Note: The number of SSRs that can be connected in parallel can be obtained as follows:
Number of SSRs connectable=A ÷ B
A: Maximum load current at the voltage output (for driving SSRs) of each Temperature Controller
B: Input impedance of SSRs

Glossary

Alarm

Alarm

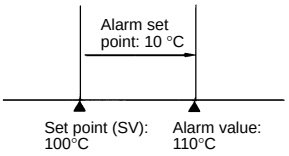
The Temperature Controller compares the process value and the preset alarm value, turns the alarm signal ON, and displays the type of alarm in the preset operation mode.

Deviation Alarm

The deviation alarm turns ON according to the deviation from the set point in the Temperature Controller.

Setting Example

Alarm temperature is set to 110°C.



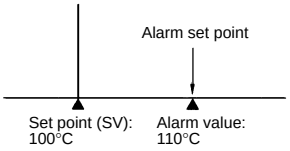
The alarm set point in the above example is set to 10°C.

Absolute-value Alarm

The absolute-value alarm turns ON according to the alarm temperature regardless of the set point in the Temperature Controller.

Setting example

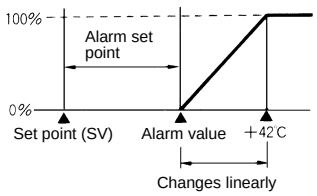
Alarm temperature is set to 110°C.



The alarm set point in the above example is set to 110°C.

Proportional Alarm

The proportional alarm enables simple heating and cooling control, in which the control output of the Temperature Controller is used for heating and the alarm output is used as cooling control output. The 0% control output is turned ON with the alarm value and the 100% control output is turned ON with the proportional upper limit, between which the control output changes linearly.

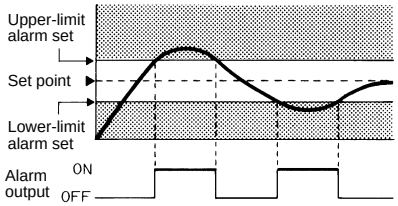


Standby Sequence Alarm

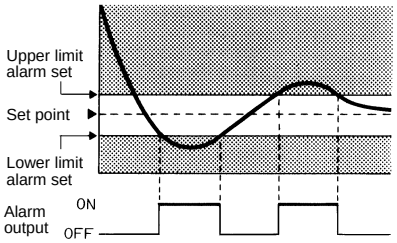
It may be difficult to keep the process value outside the specified alarm range in some cases (e.g., when starting up the Temperature Controller) and as a result the alarm turns ON abruptly. This can be prevented with the standby sequential function of the Temperature Controller. This function makes it possible to ignore the process value right after the Temperature Controller is turned on or right after the Temperature Controller starts temperature control. In this case, the alarm will turn ON if the process value enters the alarm range after the process value has been once stabilized.

Example of Alarm Output with Standby Sequence Set

Temperature Rise

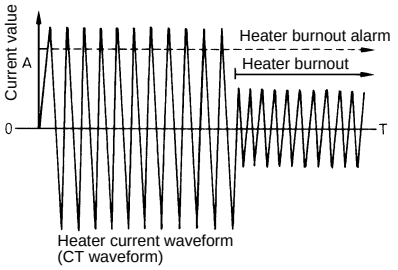


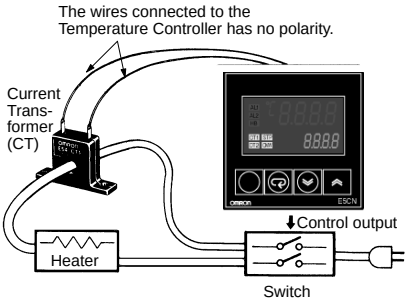
Temperature Drop



Heater Burnout Alarm (Single-phase Use Only)

Many types of heaters are used to raise the temperature of the controlled object. The CT (Current Transformer) is used by the Temperature Controller to detect the heater current. If power interruption is caused by heater burnout, the Temperature Controller will detect the heater burnout from the CT and will output the heater burnout alarm.

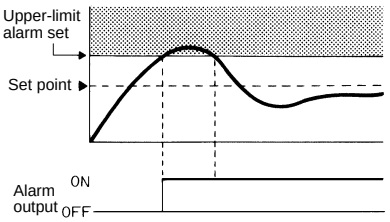




Alarm Latch

Applicable Models: E5□N

An alarm will usually turn OFF if the process value is not within the specified alarm range. The latch alarm function makes it possible to keep the alarm output turned ON once the alarm is triggered.



LBA

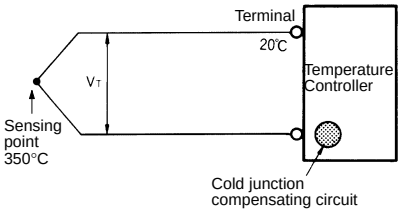
Applicable Models: E5□K

The LBA (loop burnout alarm) is a function to turn the alarm signal ON by assuming the occurrence of control loop failure if there is no input change with the control output set to the highest or lowest value. Therefore, this function can be used to detect control loop errors.

Temperature Sensor

Cold Junction Compensating Circuit

The thermocouple generates a thermo-electromotive force according to the difference in temperature between the hot junction and cold junction. The temperature sensor data will change if there is any change in the temperature of the cold junction regardless of whether there is any change in the temperature of the hot junction. Therefore, another temperature sensor is employed to detect the temperature of the cold junction connected to the thermocouple and make an electrical compensation so that the temperature of the cold junction will be always 0°C. This compensation is called cold junction compensation.



The thermo-electromotive force VT is calculated from the following formula:
VT = K (350 – 20)

Condition:
The terminal temperature is 20°C.

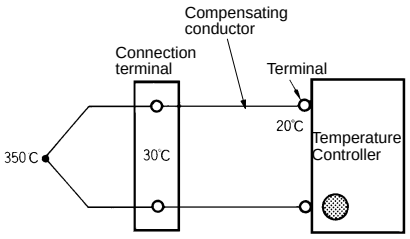
$V_T = \underline{K\ (350 - 20)} + \underline{K \bullet 20} = K \bullet 350$

Thermo-electromotive force of thermocouple

Thermo-electromotive force generated by cold junction compensating circuit

Compensating Conductor

An actual application has a sensing point that may be located far away from the Temperature Controller. Special-conductor thermocouples are expensive. Therefore, the compensating conductor is connected to the thermocouple in such a case. The compensating conductor must be in conformity with the characteristics of the thermocouple, otherwise precise temperature sensing will not be possible.



Example of Compensating Conductor Use

$\underline{K\ (350 - 30)} + \underline{K\ (30 - 20)} + \underline{K \bullet 20} + K \bullet 350$

Thermo-electromotive force of thermocouple

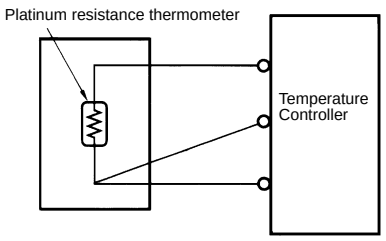
Thermo-electromotive force generated by cold junction compensating circuit

Thermo-electromotive force through compensating conductor

Three-wire Resistance Thermometer

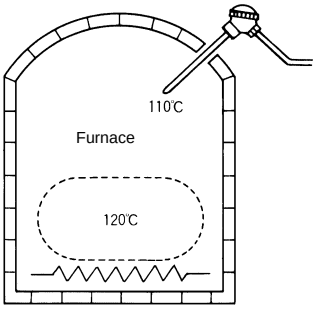
The three-wire platinum resistance thermometer is used by OMRON's Temperature Controller. One of the resistance conductors of the three-wire resistance thermometer is connected to two wires and the other resistance conductor is connected to another wire, the wiring of which eliminates the influence of the resistance of the extended lead wires.

Connection of Three-wire Platinum Resistance Thermometer



Input Compensation

A preset point is added to or subtracted from the temperature detected by the temperature sensor of the Temperature Controller to display the process value. The difference between the detected temperature and displayed temperature is set as an input compensation value.



Input compensation value: 10°C
(Displayed value is 120°C)
(120 – 110 = 10)

Platinum Resistance Thermometer

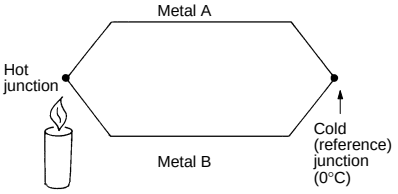
The resistance of a metal will increase if the temperature of the metal increases. This is especially true if the metal is platinum. The platinum resistance thermometer makes use of the nature of platinum (e.g., its resistance increases with the temperature rise) by incorporating a fine platinum wire wound around a mica or ceramic plate.

Thermocouple

A thermocouple consists of two different metal wires with the ends connected together. If the two contacts are different in temperature, the thermocouple will generate a voltage called thermo-electromotive force. The power of thermo-electromotive force depends on the metals. The temperature sensor making use of this voltage as input to the Temperature Controller is called a thermocouple.

Hot Junction and Cold Junction

A thermocouple has hot junction and cold junction. The hot junction is for temperature sensing and the cold junction is connected to the Temperature Controller.

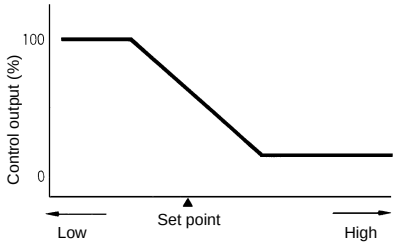


Glossary

Output

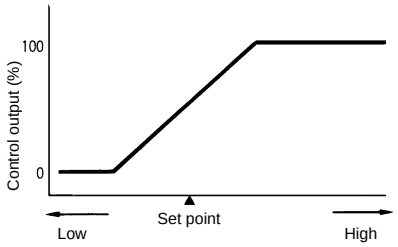
Reverse Operation

The Temperature Controller in reverse operation will increase control output if the process value is lower than the set point (i.e., if the Temperature Controller has a negative deviation).



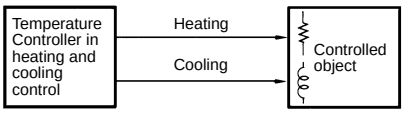
Direct Operation

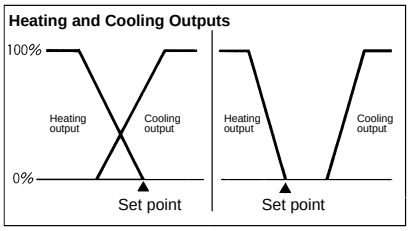
The Temperature Controller in normal operation will increase control output if the process value is higher than the set point (i.e., if the Temperature Controller has a positive deviation).



Heating and Cooling Control

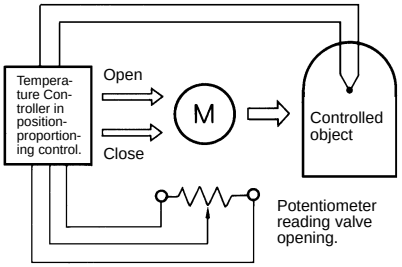
The controlled object may be in heating and cooling control if the temperature control of the controlled object is difficult with heating alone. A single Temperature Controller has heating control output and cooling control output.





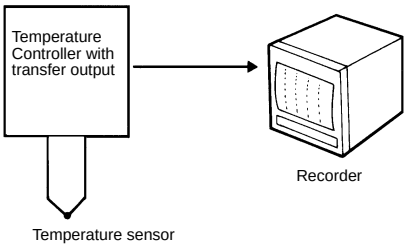
Position-proportioning Control

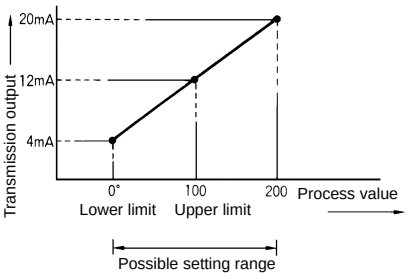
This control is also called ON/OFF servo control. If a valve with a control motor is applied to temperature control with the Temperature Controller and a potentiometer, the Temperature Controller will read the valve opening from the potentiometer and will turn the open and close signals ON along with control output for temperature control.



Transfer Output

The Temperature Controller with current output independent from control output is available. The process value or set point within the available temperature range of the Temperature Controller is converted into 4- to 20-mA linear output that can be input into recorders to keep the results of temperature control on record. The upper and lower limits can be set for transfer output in the E5CK with transfer output board. Therefore, the transmission output between the upper and lower limits will be turned ON if the E5CK with transfer output board is used.

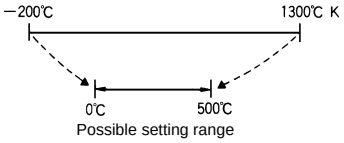




Setting

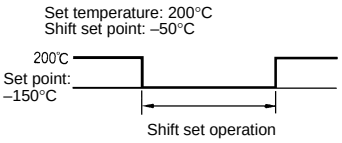
Set Limit

The set point range depends on the temperature sensor and the set limit is used to restrict the set point range. This restriction affects the transmission output of the Temperature Controller.



Shift Set Operation

The set point can be shifted to a different value to be used by the Temperature Controller in shift set operation.

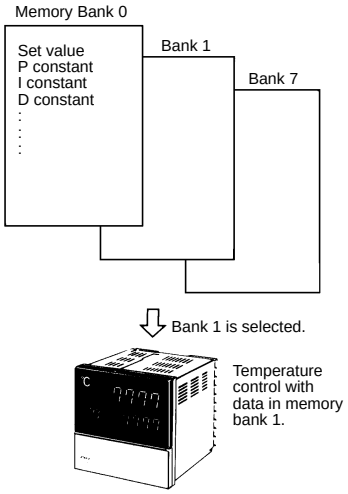


Multiple Set Points

Two or more set points independent from each other can be set in the Temperature Controller in control operation.

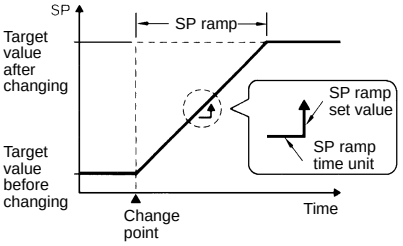
8 Banks

The Temperature Controller stores a maximum of eight groups of data (e.g., set value and PID constant data) in built-in memory banks for temperature control. The Temperature Controller selects one of these banks in actual control operation.



SP Ramp

The SP ramp function controls the target value change rate with the variation factor. Therefore, when the SP ramp function is enabled, some range of the target value will be controlled if the change rate exceeds the variation factor as shown below.



Remote SP Input

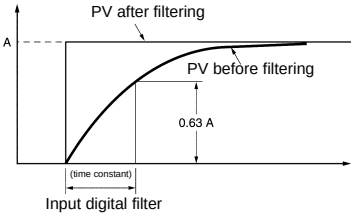
SPs can be set using external 4- to 20-mA input signals. If the remote SP function is enabled, 4- to 20-mA input will be used for remote SP input.

Event Input

Event input signals are external signals used to change SPs and select RUN/STOP patterns.

Input Digital Filter

The input digital filter processes input signals according to the set digital filter time constant. The operation of the digital filter is shown below.



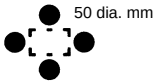
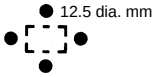
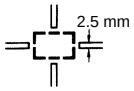
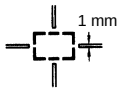
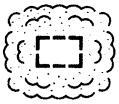
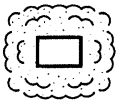
Standards

■ Protection Degree

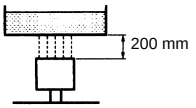
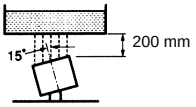
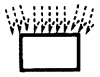
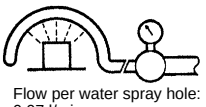
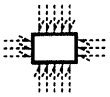
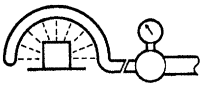
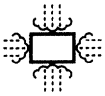
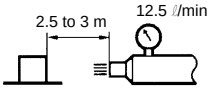
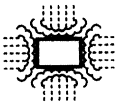
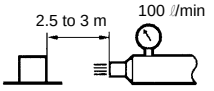
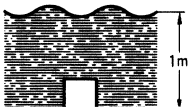
IP - □ □ □
1 2 3

Protection Specification Code (International Protection) (IEC529)

1. Protection Against Solid Foreign Objects

Grade	Protection	Criteria
0		No protection
1		Full penetration of 50-mm diameter of sphere not allowed. Contact with hazardous parts not permitted.
2		Full penetration of 12.5-mm diameter of sphere not allowed. The jointed test linger shall have adequate clearance from hazardous parts.
3		The access probe of 2.5-mm diameter shall not penetrate.
4		The access probe of 1.0-mm diameter shall not penetrate.
5	Dust protected 	Limited ingress of dust permitted (no harmful deposit).
6	Dust-tight 	Totally protected against ingress of dust.

2. Protection Against Harmful Ingress of Water (IEC Standards)

Grade	Protection	Criteria	Examination method
0	No particular protection	No protection	No test
1	Rain	Protected against vertically falling drops of water.	Spray water downwards in vertical direction for 10 minutes using a water-dripping test device. 
2	Rain	Protected against vertically falling drops of water with enclosure tilted 15° from the vertical.	Tilt by 15° and spray water for 10 minutes (2.5 minutes in each direction) using a water-dripping test device. 
3	Rain 	Protected against sprays to 60° from the vertical.	Spray water up to 60° in both directions from the vertical axis for 10 minutes using the test device shown below.  Flow per water spray hole: 0.07 l/min
4	Water splash from all directions 	Protected against water splashed from all directions; limited ingress permitted.	Spray water from all directions for 10 minutes using the test device shown below.  Flow per water spray hole: 0.07 l/min
5	Housing jets from all directions 	Protected against low-pressure jets of water from all directions; limited ingress permitted.	Spray water from all directions for one minute per m^2 of external surface area and for a total time of no less than 3 minutes using the test device shown below.  Discharging nozzle dia.: 6.3
6	Strong hosing jets from all directions 	Protected against strong jets of water, e.g. for use on ship decks; limited ingress permitted.	Spray water from all directions for one minute per m^2 of external surface area and for a total time of no less than 3 minutes using the test device shown below.  Discharging nozzle dia.: 12.5
7	Temporary immersion (see note 1)	Protected against the effects of immersion between 15 cm and 1 m.	Submerge for 30 minutes at the depth of 1 m (if the device is located lower than 850 mm). 
8	Continuous immersion (see note 2)	Protected against long periods of immersion under pressure.	Test according to the conditions agreed upon between the manufacturer and user.

Standards

3. Protection Against Oil (by JEM (Japan Electrical Manufacturers Association Standards) Standards (JEM 1030))

Grade	Protection	Criteria	Criteria
F	Oil-proof	Protected against improper operation due to oil drops or spray from any direction.	No penetration of oil to the extent of interfering with proper operation after dropping the specified cutting oil on a test device for 48 hours at a rate of 0.5 ℓ per hour.
G	Oil resistant	Protected against penetration of oil drops or spray from any direction.	No penetration of oil after dropping the specified cutting oil on a test device for 48 hours at a rate of 0.5 ℓ per hour.

NEMA (National Electrical Manufactures Association)

Conversion from NEMA to IEC529 (Reverse conversion is not possible.)

NEMA250	IEC529
1	IP10
2	IP11
3	IP54
3R	IP14
3S	IP54

NEMA250	IEC529
4, 4X	IP56
5	IP52
6, 6P	IP67
12, 12K	IP52
13	IP54

Note: Based on the Appendix A of the NEMA Standard. Classification of the NEMA enclosure rating differs from that of the IEC529 in corrosion resistance, rust resistance, and watertightness.

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